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Improvements in and relating to Blast Mitigation Structures

This invention relates to blast mitigation structures which use liquid-filled containers such as water-filled flexible bags, arranged so as to mitigate the effects of a blast or explosion by dissipitating and/or converting to heat the resulting blast energy.

Blast mitigation structures using water-based technology are well known and for instance US patent no. 4836079, the disclosure of which is incorporated herein by reference, teaches various embodiments of bomb blast inhibitors which can be inflated with air, placed around e.g. a bomb, and then filled with water, the water then acting to suppress or otherwise mitigate against the effects of any ensuing explosion. This concept has been taken at least a further step by the use of, effectively, twin-walled containers as taught in GB2374625A, the disclosure of which is also incorporated herein by reference, which include internal connectors between opposing walls and surfaces, such as through the use of drop stitch material, by which the container is prevented from bulging outwardly, the main benefit being that a protective wall can then be erected which is taller than the width of the base without the container collapsing or toppling over under the weight of water.

A problem with such prior art devices is that although they are very efficient in safely dealing with the effects of explosions, given that the containers themselves are not made of rigid material and hence when fragmented by an explosion such fragments do not constitute flying debris equivalent to shrapnel, it will be apparent that the inflation of such containers by air followed by substitution of air under pressure for water under pressure by e.g. the use of a

suitable pressure relief valve arrangement, still necessarily takes some time to complete a structure comprising multiple containers. In the event of e.g. a car bomb having to be dealt with it will be understood that this may jeopardise the safety of personnel erecting such blast mitigation structures around the car. In addition, where the car bomb is of the "dirty" type, such as one involving the explosive spread of e.g. radioactive materials or poisonous chemicals, a primary consideration is not just to protect personnel in the immediate vicinity of the bomb but also to minimise the spread of the pollutant such that it is wholly or substantially kept within the immediate vicinity of the explosion, thereby requiring a presence of a blast mitigation barrier which completely covers the vehicle including the top of the vehicle.

The present invention is derived from the realisation that, especially when dealing with potential car bombs i.e. suspect vehicles, speed is of the essence in quickly and safely erecting a blast protection structure around the vehicle using rupturable liquid-filled containers such as water-filled bags, but in conjunction with means for rapidly deploying the containers therearound.

According to the invention, there is provided a blast mitigation device comprising one or more inflatable, rigidisable, free-standing arched frames comprised of one or more compartments, the or each compartment being fillable, in use, with a gaseous medium under pressure, and one or more water-fillable containers supported or supportable by the or each free-standing frame, which water-fillable container(s) form a blast mitigation structure in use.

Conveniently, the or each container(s) making up the inflatable generally rigid free-standing arched inflatable frame is made up of individual

compartments of drop stitch material by which respectively opposite outer walls are prevented or inhibited from bulging outwards under pressure, although in an alternative construction the compartments are simply made up of pressurisable material which bulges outwardly under pressure to assume e.g. a part cylindrical shape which nevertheless, in combination, are sufficiently rigid to support the weight of water from the water-fillable containers.

Preferably, the water-fillable containers are also made of drop stitch material so as to increase the total rigidity of the entire structure in use, although it will be apparent that provided the water-fillable containers are sufficiently densely packed around and over the or each arched frame or frames so as to ensure that a blast mitigation structure is present substantially entirely around e.g. an explosive device, the use of the, relatively expensive drop stitch material may be dispensed with and simple containers may be used in substitution for containing the water.

The invention therefore provides a blast mitigation device having few or no hard components, which could otherwise become shrapnel in the event of e.g. a car bomb exploding. A further advantage is that such a blast mitigation device may take the form of a tunnel with an arched roof which may be quickly erected around e.g. a suspect vehicle by the simple expedient of inflating the containers making up the generally rigid free-standing frame or frames until a generally rigid structure is formed and then filling the water-fillable containers with water, all of which may be done remotely or semi-remotely, whereafter e.g. a suspect vehicle may be simply left in place with a suitable warning to keep away from it, or overt action may be taken by the use of a disruptor charge

placed by a remotely controlled vehicle. The invention also envisages in one embodiment that one or more of the inflatable containers making up the one or more free-standing frames may be removable along with corresponding containers for water to allow for the placement of such a charge, whereafter they may be replaced prior to detonation of the charge.

Conveniently, two or more devices are used, each being in the form of a walled tunnel having an arched roof, there being one closed end, made up, in combination of air inflatable generally rigid or rigidisable containers and containers filled or fillable with water, the walled tunnel also having an open end which may e.g. be used to allow the structure to be moved over e.g. one half of a vehicle to substantially enclose that half, the other of such structures being used to substantially enclose the other half of the vehicle.

Preferably, each rigidisable arched frame is made of independently inflatable semi-arched halves connectable at the apex of the arch through the use of e.g. webbing, strapping, Velcro® fasteners or other such non rigid fastener means. These semi-arched halves may themselves be formed by "pinching" one side of an otherwise parallel-walled layer of drop stitch material to form, when inflated, a semi-arch, the pinching occurring at regular intervals radially from a sidewall portion of the structure to the apex of the arch.

In order to prevent the "legs" of the arched frame from splaying outwardly with the weight of water contained in the water filled containers webs, strapping or other such means may be connected or connectable between such opposing legs.

Preferably, where two devices making up a rigidisable frame are used each has an independent air inlet for forming the inner wall and an independent air/water inlet for filling the outer containers, which each conveniently including a respective air relief valve adjacent the apex of the arch so that after the water fillable containers are first filled with air in order to assume their desired shape, they can thereafter be filled with water and air may thereafter be allowed to escape without altering the overall shape of the blast mitigation device.

Conveniently, a chicane may be built into the or each free-standing device whereby access to the inside of the structure is possible but is indirect, such that a subsequent blast from an explosive device always encounters the water-fillable containers. This may simply be in the form of a stepped wall, or if two blast mitigation structures are to be used in tandem they may each be of size sufficient to enclose one entire end of the vehicle plus an amount by which access may be gained through such a chicane, such that an opposing pair of such structures meet each other in a stepped configuration.

Conveniently, the or each blast mitigation device also incorporates means by which it may be inflated remotely, such as by including integrally formed air and water filling pipes which may simply be unreeled from the deflated components of the device such that the filling takes place at a distance from the suspect device/vehicle. Sensing apparatus may also be integrally incorporated to e.g. 'sniff' the interior of the device when it is erected for the presence of explosives material. A camera may also be provided integrally with the device to visually monitor the inside thereof once it has been erected. Electric wires may be included for these and other such devices which again may be unreeled and

attached to e.g. monitoring apparatus remote from the structure to thereby minimise the danger to personnel.

The invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a front elevation of an inflated blast mitigation structure according to a first embodiment of the invention,

Figure 2 is a side elevation of the structure shown in Figure 1,

Figure 3 is a plan view of a second embodiment of the invention having chicane access means, and

Figure 4 is a part-exposed end view of a third embodiment of the invention in which the rigidisable arched frame is made up of independently inflatable semi-arched halves,

Figure 5 is a sectional plan view of the plane 'A'-'A' of Figure 4,

Figure 6 is a side view of the embodiment shown in Figure 4,

Figure 7 is a schematic view showing how two of the containers shown in Figure 6 are joined together by a series of flange valves and

Figure 8 is an end view of one of the containers of Figure 7 showing the flange valves.

Referring firstly to Figures 1 and 2, there is shown a front elevation of a fully inflated and assembled blast mitigation device 1 in which for clarity its individual component segments are shown made of transparent material such that the inside may be viewed. The inflated device 1 takes the form of an arched tunnel which may be erected around a suspect vehicle 2 such that in the event it explodes the device 1 is able to mitigate against the effect of the subsequent

blast. This is primarily achieved by the presence of a wall of water around the vehicle 2 disposed in water fillable interconnected bags or containers 3, some of which are arcuate, to form an arched shell of water around the vehicle 2. This shell is supported by an arched inner tunnel of inflatable bags or containers 4 which are also pneumatically interconnected such that when filled under pressure by e.g. air from a high pressure hose it becomes a free standing frame which provides sufficient support to counter the weight of the water in the containers 3.

In order to increase their rigidity the gas fillable containers 4 are made of drop stitch material such that their outer walls are prevented or inhibiting from bulging outwards under the internal pressure of gas from within and where the device is intended to form a large structure preferably the outer containers or bags 3 are also made of drop stitch material as opposed to being, as shown in Figure 1, simple bags which can be filled with water and by virtue of the volume of water be expanded to their limit.

A rear wall 5 may also be provided although not necessarily integrally and may be of solid material or may itself be formed of e.g. water fillable bags or containers made of drop stitch material which may be self-supporting or partly supported by the arched tunnel of gas-filled bags or containers 4.

In Figure 2 a pair of such blast mitigation devices 1 are shown disposed open end on end to each other for totally enclosing the vehicle 2 and in order to gain access to the vehicle for e.g. inspection to investigate for the presence or otherwise of explosives material one or more of the bags or containers 3, 4 may be removable for such purpose, or access may be gained via a suitable

removable panel in the end wall 5 of each device 1. Alternatively, an arrangement like that shown in Figure 3 may be adopted where internal walls are shown in dotted outline. In this arrangement a doorway 6 is shown cut into the end wall 5 to allow access into the interior and this may be simply rectangular rather than being arched. In order to mitigate against the effects of any subsequent explosive blast exiting the device 1 through the doorway 6 a water-filled wall 7 of generally "L" shape is provided, preferably made of drop stitch material and pneumatically connected to the bags 3 if made of drop stitch material so that a single water inlet valve may be used to erect the entire wall of water around the suspect vehicle 2 after the gas-fillable bags 4 have been fully erected.

As will be apparent, access to the inside of the device 1 via the doorway 6 may enable e.g. a remotely-controlled robotic vehicle to subsequently enter the free-standing frame of pressurised bags 4 to carry out an inspection of the vehicle and/or place a disruptor charge before retreating, or even physically destroy the suspect device by e.g. discharge of a shotgun.

Referring now to the preferred embodiment shown in Figures 4-6, the blast mitigation devices 1 are made up of semi-arched halves 1a, 1b which are connected at their apex 8 by any suitable fastener means such as opposing strips of Velcro® or some other such non rigid fastener means. Each of the semi-arched halves 1a, 1b, are formed from originally planar drop stitch material which are then pinched together on one side at regular intervals 9, 10, 11 in respect of the subsequently semi-arched half 1a and 12, 13, 14 in respect of semi-arched half 1b. However, in this embodiment, unlike the structure

described with reference to Figures 1 to 3, each blast mitigation device 1 has just two outer containers 3a for containing water, one for each semi-arched half 1a, 1b, and a pair of respective inner containers 4a, for containing air under pressure. In this embodiment, the containers 3a, 4a are made of drop stitch material such that the desired generally arched shape is retained even when the containers 4a are inflated with air or some other suitable gas such as nitrogen under pressure and the containers 3a are filled with water intended to mitigate against the effects of an explosion occurring within the arched tunnel formed by the devices 1.

Each half 1a, 1b may selectively be provided with a large inlet pipe 15 suitable for initially supplying air under pressure to both containers 3a, 4a to form the structure as shown in Figure 4, whereafter through the use of a non-return valve 16 in the inlet pipe 15 and pressure relief valve 17 adjacent the apex 8 the outer containers 3a can then be exhausted of air and filled instead with water to complete the required structure.

In order to prevent outward splaying of the lower parts of the halves 1a, 1b near to the ground under the weight of water, strapping 18 is used to connect the lower portions of the semi-arched halves 1a, 1b in a manner best illustrated with reference to Figure 5 where four such straps are used to prevent outward splaying of the semi-arched halves 1a, 1b at regular intervals between connected blast mitigation devices 1, such connections being illustrated with reference to Figures 7 and 8. Figure 7 shows a pair of devices 1 joined together by two-piece flange valves 19 comprised of a male flange half 20 fixed to and through an end wall 21 (shown in Figure 8) of one of the blast mitigation devices

1 and a female flange half 22 fixed to and extending through the opposite wall 23 of an adjacent blast mitigation device 1 such that any number of devices 1 may be linked together to form a single blast mitigation structure requiring just a single pair of inlet pipes 16, one for each half, 1a, 1b. Hence, by the use of the flange valves 19 a large blast suppression structure comprised of interconnected individual devices 1 may therefore be constructed and filled with air and water as required.

As shown in Figures 5 and 6, to complete the structure end containers 24 may be provided and be fillable via their own water inlet pipes 25 and attendant valves (not shown), the containers 24 being releaseably secured to devices 1 at respective ends of the blast mitigation structure, such as by the use of Velcro® strips or other such fastening means, to thereafter completely enclose e.g. a suspect vehicle.

Whilst, as aforesaid, drop stitch material has been used to form blast mitigation structures in which, generally, initially air under pressure is replaced with water, it will be understood that the weight of water imposes an upper practical limit upon the size and shape of such structures without them requiring separate support. The present invention therefore provides an elegant solution to this problem to the extent that it has been found that essentially air-filled containers made of drop stitch material can be used to provide sufficient support, either separately or in conjunction with support required by the presence of water in the containers fillable therewith, depending upon whether or not the water fillable containers are also made of drop stitch material, such that they also enjoy integral support as a consequence.